

Apollo Mission Support

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The support provided by the DSN to the Manned Space Flight Network during the Apollo 15 mission is described. Support was provided from four 26-m (85-ft) DSN stations, the Goldstone 64-m (210-ft) antenna, the Ground Communications Facility, and the Space Flight Operations Facility. Pre-mission and mission activities are discussed and a brief mission description is included.

I. Introduction

The DSN support provided to the MSFN for past Apollo lunar missions has been described in Refs. 1 and 2 and earlier issues of the Space Programs Summary Volume II series. This article describes the support provided for the Apollo 15 (AS-510) mission, the fourth successful manned lunar landing and the first of the new "J" type missions devoted almost exclusively to scientific objectives as opposed to the engineering emphasis of the earlier "H" missions.

II. Mission Description

Apollo 15, the eighth manned Apollo mission flown above the three-stage Saturn V launch vehicle, carried astronauts David R. Scott (Commander), Alfred M. Worden (Command Module Pilot), and James B. Irwin (Lunar Module Pilot). The mission goal was exploration of the canyon-like Hadley Rille and the Apennine foothills. A second goal was the collection of scientific data while in an extended lunar orbit phase.

Launch from Cape Kennedy Pad 39A occurred at 13:34:00.79 GMT on July 26, 1971, at a launch azimuth of 80.088 deg. Injection into translunar trajectory over the Pacific Ocean occurred midway through the second revolution in Earth parking orbit with a 5-min 47-s burn of the S-IVB stage engine. Translunar injection (TLI) put the spacecraft on a direct trajectory toward the Moon, making Apollo 15 the first mission to abandon entirely the "free-return" trajectory which requires no propulsion to return to Earth. This direct trajectory conserves fuel for the critical landing sequence.

Following TLI the Command Service Module (CSM) separated from the booster, docked with the unattended Lunar Module (LM), and extracted the LM from the S-IVB. The S-IVB was directed by ground command toward a crash on the Moon as an additional calibration of the seismometers left there by the Apollo 12 and 14 missions. The impact occurred at 20:58:41.75 GMT on July 29 at lunar coordinates 1.0°S and 11.87°W, about 185 km (100 nmi) from the Apollo 14 landing site.

Midcourse Correction 1 was deleted due to the accuracy of the TLI maneuver. During the translunar cruise a short was noted in the CSM Service Propulsion System thrust indicator circuit. This short would have caused problems during maneuvers, and a set of workaround procedures set developed. Midcourse Correction 2 was not needed, but was scheduled as a test of these new procedures. Midcourse Correction 3 was deleted, and Midcourse Correction 4 was a short 0.92-s burn.

Other anomalies occurring during translunar cruise were a broken cover glass on the LM range/range rate meter (no impact), a chlorinator valve leak (tightened), and one strong voltage dip on the spacecraft ac and dc power busses. The latter problem occurred only two seconds after loss of uplink caused by a DSS 11 transmitter trippoff, prompting some concern that the two events were related. Later investigation showed that a CSM circuit breaker feeding some lighted pushbuttons on the spacecraft computer console had tripped. A short large enough to trip the circuit breaker would also have caused the voltage dips. The circuit breaker was never reset.

Shortly before entering lunar orbit, the astronauts blew off a door covering the Scientific Instruments Module (SIM) of the Service Module (see Fig. 1). The SIM bay, a first for *Apollo 15*, carries scientific instruments for observation of the Moon from lunar orbit. The instruments include a gamma ray spectrometer developed at JPL, an X-ray spectrometer, an alpha particle spectrometer, a mass spectrometer, a laser altimeter, a 7.62-cm (3-in.) mapping camera, and a 60.96-cm (24-in.) panoramic camera.

A successful lunar orbit insertion (LOI) burn of 400.7 s put the spacecraft into a 315- by 108-km (170- by 58-nmi) orbit. Two orbits later a descent orbit insertion (DOI) burn lowered the spacecraft to a 109- by 17.1-km (58.5- by 9.2-nmi) orbit. A DOI trim maneuver later raised this perilune to 17.8 km (9.6 nmi).

During lunar orbit 12 the CSM and LM separated with astronauts Scott and Irwin in the LM preparing for descent to the lunar surface on orbit 14. The undocking was delayed approximately 26 min due to a poor connection on the umbilical wire to the CSM docking probe. Shortly after undocking the CSM maneuvered into a near-circular orbit 121 by 102 km (65.2 by 54.8 nmi).

The approach to landing was steeper (25 deg) than any Moon lander before, providing extra clearance from the 3.66-km (12,000 ft) Apennine peaks. The LM made a normal landing about 121.92 m (400 ft) northeast of the target. The actual landed location is 26.0835°N and 3.665°E. Soon after landing the astronauts conducted a standup extravehicular activity (SEVA), which involved depressurizing the cabin, opening the top (docking) hatch, and making a photographic and visual survey of the landing site from the top hatch. This activity was partly to acquire visual reference points for subsequent navigation chores. A sleep period followed, during which one of the two bistatic radar experiments was conducted with the orbiting CSM.

During the first extravehicular activity (EVA) period the astronauts deployed the lunar rover (Fig. 2), used for the first time on *Apollo 15*. Although the front steering was inoperative, the rear steering was sufficient, and the crew drove to several small craters where scientific exploration, surface sampling, and photographic documentation were completed. Observers on Earth were able to watch the activities at each stopping point, thanks to the new Lunar Communications Relay Unit (LCRU) (Fig. 3). On previous missions the astronauts' VHF transmissions were relayed to Earth by the LM, but with the rover the men would travel beyond VHF range from the LM. Hence, the LCRU was designed as a portable S-band/VHF transceiver, normally resting on the rover, to keep the astronauts in contact with mission control. In addition to voice and telemetry on the downlink, the video output of the LM camera could be transmitted. The uplink carried capcom voice plus television commands (pan, tilt, zoom). A special assembly on the rover provided a mounting platform for the LM TV camera and actuated the camera according to the received commands.

At the end of EVA number 1, the crew deployed the *Apollo* Lunar Surface Experiments Package (ALSEP), which contains a seismometer and several fields and particles experiments. The crew then re-entered the LM for an eating and sleeping period during which the second bistatic radar experiment was conducted with the CSM.

At the start of the second EVA, the steering problem in the rover was cleared by resetting a circuit breaker. It was with a fully functioning rover that the astronauts drove to another series of craters for sample collection and scientific investigation, and returned to complete the deployment of the ALSEP package.

After a third eating and sleeping period, the crew made their third and last lunar excursion. This time the route took them along Hadley Rille for some spectacular vistas and a chance to collect samples from what is believed to be lunar bedrock. The total distance traveled during all three EVAs was 28 km, and the rover was driven at a maximum speed of 12 km/h. A total of 83 kg (183 lb) of Moon rock was collected and nearly 3.2 km (2 mi) of film was exposed.

It was less than four hours after the third EVA when the Lunar Module blasted off the lunar surface to rejoin the orbiting CSM. The liftoff was witnessed on Earth via the LCRU and its associated TV camera. Rendezvous and docking were normal and all lunar samples were transferred to the CSM. During a pressure check prior to LM jettison, a leak was detected in the LM/CSM tunnel. Removal and inspection of the hatch disclosed no reason for the leak, and on reinstallation the leak was gone. The pressure check was continued for over an hour, and the LM was finally jettisoned on revolution 52, one orbit later than planned. The LM was maneuvered to a crash on the Moon for another calibration of the three seismometers. Crash occurred at coordinates 26.36197°N and 0.25345°E, 92.6 km (50 nmi) from the *Apollo 15* site.

The CSM remained in lunar orbit almost two days longer conducting orbital science experiments with emphasis on the SIM bay experiments. This extended lunar orbit stay is another *Apollo* "first" in keeping with the science goals of the "J" type mission. The film packages from the SIM bay cameras were retrieved by the Command Module Pilot who took a "spacewalk" during transearth cruise. Shortly before transearth injection, the crew released a Particle and Fields Subsatellite (P&FS) (Fig. 4) into an orbit of 139 by 100 km (75.1 by 57.3 nmi) at an inclination of 151.3 deg. The subsatellite has a coherent S-band transponder for lunar mass concentration (mascon) studies at JPL.¹

The accuracy of transearth injection (TEI) was such that only one short midcourse burn was required shortly before Earth atmosphere entry. *Apollo 15* landed at approximately 26°4'N and 158°4.5'W some 480 km (300 mi) north of Hawaii.

Table 1 shows the mission event times and Table 2 gives a summary of television coverage.

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III. Requirements for DSN Support of *Apollo 15*

A. DSN 26-m Antenna Stations

As was done with previous *Apollo* lunar missions, DSSs 11, 42, and 61 were committed to support *Apollo 15* under direct MSFN/MSC control. The responsibilities at these stations have changed, however.

Previously, the stations had two control rooms or "wings," one MSFN and one DSN, and a set of common equipment, including antenna, servo, microwave, masers, and power amplifiers, with a complicated switch to select the control room to be connected to the common equipment. To avoid needless construction, the DSN wing was designated to be the control room for the new 64-m antennas now being built adjoining DSSs 42 and 61. All equipment to operate the 26-m antenna in either DSN or MSFN mode was moved into what had been called the MSFN wing, and the DSN, with MSFN concurrence, assumed responsibility for maintenance and operations of the entire station. DSS 11 was similarly configured to maintain network standardization.

In order to support the increased DSN responsibilities at these stations, the DSIF insisted on a dedicated voice line to each station during its tracking period. The line was for use only if the station had a problem and needed immediate assistance from the SFOF. No routine traffic was to appear on this line. In addition, the existing voice line from the DSN Operations Chief to the MSFN Operations Chief was extended at each end to allow the DSIF Operations Advisor to talk directly to the MSFN Network Support Team.

A new requirement on the 26-m stations was for the reception of the LCRU downlink at 2265.5 MHz, lower in frequency than any previously received *Apollo* signals. The uplink was on the same frequency as the LM uplink. The P&FS was also to be tracked, but this presented no problem since the uplink and downlink frequencies are the same as the LM.

In view of past problems with transmitter tripoffs, the DSN was required to modify its battleshort function at DSSs 11, 42, and 61. The modification left only one interlock, the arc detector, in operation. No other personnel safety or equipment interlocks will function when the battleshort is engaged. The battleshort is used during brief, mission-critical events, such as LM touchdown, when loss of uplink is very undesirable. In the event of a false interlock, there would be no interruption of the

uplink. If the interlock is genuine, however, the power amplifier or its power supply would probably be destroyed and be unavailable for the remainder of the mission. Without the battleshort, interlock tripoffs are usually cleared rapidly, losing only a few seconds of uplink lock. Thus, an agonizing tradeoff must be made over use of the battleshort.

B. DSS 14

The Mars station, DSS 14, was required to receive voice, telemetry, biomedical, and TV, and relay the data to the Goldstone Prime MSFN station (GDS). Specific requirements existed for low lunar orbits, touchdown, EVA television, and LM crash. Coverage was also desired for television during translunar coast.

C. Precision Doppler Data

As part of a continuing study of lunar potential anomalies (mascons), DSS 14 was required to provide precision high-speed doppler recordings of the CSM and LM during low lunar orbits and of the LM during the descent phase and later during the crash. In cooperation with the principal experimenter for this JPL study, a set of internal DSN requirements was developed to make use of the high-resolution doppler data available from DSN stations equipped with doppler resolvers. Four passes at DSS 51 were scheduled for this purpose. DSS 51 was made available by tracking *Mariner* Mars 1971 from DSS 62. This was fortunate because the Moon was at a low declination, and DSS 51 had long view periods. Additionally, the desired doppler was recorded at DSS 14 during the passes that had previously been scheduled for official *Apollo* support. Preliminary results from the same experiment on *Apollo 14* are given in Ref. 3.

A related *Apollo* requirement was for high-speed strip-chart recordings of DSS 14 received signal level during orbit 3 of the CSM and the crash of the LM.

D. Bistatic Radar Experiment

DSS 14 was required to conduct another bistatic radar experiment as had been done during *Apollo 14* (see Ref. 2). The requirements had been expanded to encompass two orbits, 17 and 28, in place of the one orbit on *Apollo 14*. The experiment consists of receiving the CSM downlink signal, which has been reflected from the lunar surface, at DSS 14 in two orthogonal polarizations simultaneously. From the recorded signal characteristics deductions can be made as to the nature of the lunar soil.

E. ALSEP Support

The ALSEP transmissions are usually supported by the 9-m (30-ft) antennas of the MSFN. DSN support was requested during *Apollo 14* because the ALSEP on that mission occasionally transmitted at a high bit rate (10.6 kilobits per second) and the 26-m stations provided the necessary signal-to-noise ratio. During testing for that mission, it was found that the ALSEP uplink frequency of 2119 MHz was so far removed from the normal DSN and *Apollo* uplink frequencies as to require retuning of the klystron tubes in the ground transmitters. This retuning significantly increases the chances for internal klystron failure and caused some concern. Accordingly, before *Apollo 15* (whose ALSEP had no high bit rate), the DSN voiced its concern to the MSFN. After consultation with NASA Headquarters, it was decided that the DSN would continue with ALSEP uplink testing and operations regardless of the mission risks.

F. LCRU

Shortly before the mission the *Apollo* Project requested short tracks of the LCRU from DSS 14 on August 4, 5, 7, and 8. The plan was to conduct television surveys of the landing site after the astronauts had departed. The LCRU batteries were expected to last approximately one week. Since this activity is not intimately related to manned flight support, a ruling was requested from NASA Headquarters on the relationship between the LCRU after LM liftoff and the other unmanned mission support of the DSN. The approval was received and the requested tracking was scheduled by cancelling some DSS 14 support of other projects.

IV. Pre-mission Preparations and Testing

A. DSN 26-m Stations

Although the requirement to support LCRU transmissions has been known for some time, final testing of the support capability took place in early 1971 and continued until shortly before launch. The concern centered around reception of the LCRU frequency of 2265.5 MHz, below the normal *Apollo* band. Wideband masers had been installed at DSS 42 and LCRU reception there proved to be no problem. DSSs 11 and 61 had not yet received the new masers, and the bandwidth of the old maser was not sufficient to cover both *Apollo* and the LCRU. The final procedure developed through this testing was to tune one maser at each site to the lower half of the band and the other maser to the upper half. There was no redundancy in this configuration as retuning required

30 min. In addition, the output of only one maser at a time could be selected, though this selection could be changed rapidly. A similar configuration was used at DSS 14 where the masers are different but have a similar bandwidth problem. As the LCRU link is marginal from a signal strength standpoint and is critically affected by a steep gain slope, several tests were necessary to demonstrate compatibility. Before *Apollo 16*, the new wideband masers will be installed at DSSs 11, 14, and 61.

Soon after the DSS 11 reconfiguration was completed (see *Section III-A*, above) in early June 1971, power amplifier (PA) number 3 began to experience interlock tripoffs. Repeated testing and extensive component replacement (even replacement of the entire power supply) failed to improve the reliability. During the two weeks before launch, DSS 11 was reported "Red" due to the intermittent faults. This unreliability continued through the mission period, and, as of this writing, is still unsolved despite considerable efforts at diagnosis.

DSSs 11, 42, and 61 were placed under configuration control for the *Apollo 15* mission as of 00:01 GMT on July 16, 1971, and were placed on mission status by the MSFN as of 00:01 GMT on July 15, 1971. On previous missions, scheduling control of these stations reverted to the MSFN during the mission status period. In view of the increased DSN responsibilities at these stations for *Apollo 15* and beyond, the DSN planned to retain scheduling control, and the DSN/MSFN Operating Interface Procedures document (Ref. 4) reflected this plan. The MSFN, based on alleged verbal agreements, assumed that scheduling would be done by the MSFN as in the past. Accordingly, on July 15, the stations began to receive conflicting scheduling messages from both the DSN and MSFN. After several days of negotiation, MSFN scheduling was assigned control as a temporary expedient. It is felt that on *Apollo 16* these stations must be scheduled by the DSN since they will be tracking the *Pioneer F* spacecraft between *Apollo* passes.

B. DSS 14

DSS 14 conducted the normal premission tests including installation and tests of the bistatic radar experiment equipment as shown in Table 3. No scheduling problems were experienced with DSS 14 as scheduling control for the station has always been retained by the DSN.

C. DSN Predicts

Antenna pointing information for DSSs 11, 42, and 61 comes directly from Houston in the form of a 29-point

acquisition message. This message also serves DSS 14 but has been considered a backup to SFOF-generated predicts. On *Apollo 15* the 29-point message was declared the prime source of predicts for DSS 14. The SFOF continued to supply predicts, but as a backup source only. Both predict systems were tested before the mission. The 29-point system worked perfectly, but the SFOF had some minor software problems. The predicts are generated by entering a Houston-supplied state vector into the 1108 computer where the Double Precision Trajectory Program outputs a probe ephemeris tape. The tape is carried to the IBM 360/75 for processing by the predicts program. The predicts are transmitted directly by the 360. Unfortunately, both computers are undergoing a series of software updates, and with each update the interface compatibility can break down. Only a few days before launch the trajectory program in the 1108 was modified and it was necessary to add a small reformatting program to the 360 to make the data from the probe ephemeris tape compatible with the predicts program. With this last-minute modification the predicts procedure was tested and declared "Green" for launch.

V. Apollo 15 Operations

A. DSN 26-m Stations

DSSs 11, 42, and 61 successfully supported all phases of the *Apollo 15* mission. The problems experienced are noted in Table 4. As can be seen, the problems with DSS 11 transmitter number 3 continued. Three tripoffs of this transmitter were experienced during actual uplinking to the spacecraft. After the third tripoff, mission control in Houston finally acquiesced to DSN pleas (which began before launch) and declared DSS 11 transmitter number 4 as prime. After that decision there were no further uplink losses at DSS 11.

During the first pass at Goldstone shortly after TLI, the spacecraft view angles were beyond the antenna gimbal limits at the Goldstone Prime MSFN stations. Therefore, DSS 11 was required to transmit simultaneously on separate frequencies to the CSM and the instrument unit of the S-IVB booster. Although this capability has existed for the entire *Apollo* program, this is the first time that the capability has actually been used at a DSN station.

The 26-m stations tracked ALSEP several times but were never called upon to transmit the ALSEP uplink signal.

B. DSS 14

Seven *Apollo* passes were tracked as shown in Table 4. The station also tracked the LCRU twice. The station had originally been scheduled for four LCRU tracks, but after failure of the LCRU at the end of the first pass and a futile attempt at revival on the second pass, DSS 14 was released from further support.

DSS 14 supported the bistatic radar experiment as planned. The experiment was somewhat degraded during lunar revolution 17 because the spacecraft had been pitched the wrong direction, making the radiation toward the lunar surface elliptical rather than circular. Revolution 28 efforts produced good data, and was not noticeably degraded by the operator error which resulted in a brief mispointing of the antenna.

DSS 14 failed to switch to high doppler sampling rate upon LM jettison as required. LM jettison occurred at a nonstandard time, and 16 min passed before the station was advised of the event. A verbal mark will be requested from the MSFN if future missions have event-related requirements such as this.

C. DSS 51

DSS 51 tracked *Apollo* on four days as shown in Table 4. Apparently the station was not familiar with the *Apollo* requirements and took doppler samples at a one-minute rate instead of a one-second rate during part of the first pass. Unfortunately, the one-second samples were of high priority, since the spacecraft was in a very low lunar orbit at the time. The remainder of the doppler data on pass number 1 and subsequent passes was successfully recorded as required.

D. Predict Operations

The 29-point acquisition message, which was the prime source of predicts for DSS 14, was used with no problems. The messages occasionally arrived later than de-

sired, but the station was never completely without predicts.

In the SFOF, eight sets of predicts were generated during the mission and transmitted to DSS 14. One set of preflight nominal landing site predicts was generated and transmitted before the mission to DSSs 14 and 51. No problems occurred in supplying the scheduled stations with predicts.

E. GCF Participation

The DSN GCF provided voice, teletype, and high-speed data circuits to support the DSN *Apollo* operations. In addition, JPL acts as West Coast Switching Center for the NASA Communications Network and handles many non-DSN circuits in support of *Apollo*. There were no known GCF anomalies and GCF support was considered excellent. The voice lines that were scheduled to each 26-m station (*Section III-A*, above) were used only once, and deletion of this requirement is being considered.

F. SFOF Participation

The SFOF areas and equipment used for *Apollo 15* included the Operations Area, the Network Analysis Area, the *Mariner* Mars 1971 computer terminal area, the Univac 1108, and IBM 360/75 computers. The SFOF support is limited to predict generation, tracking data reception, and some off-line monitoring. The only SFOF problems were in the software area. In addition to the predict software problems mentioned in *Section V-C*, the 360 computer was unable to receive *Apollo* tracking data when tracking data from *Mariner* Mars 1971 was also being received. Therefore, the *Apollo* data had to be manually recalled from the GCF Communications Processor during inactive periods of *Mariner* Mars 1971. Other than these software problems, SFOF support was excellent.

References

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3. Sjogren, W. L., et al., "S-Band Transponder Experiment," in *The Apollo 14 Preliminary Science Report*, NASA document SP-272. National Aeronautics and Space Administration, Washington, 1971.
4. *MSFN/DSN Station Operating Interface Procedures for Support of Manned Apollo Missions*, MSFN document 508.3. Goddard Space Flight Center, Greenbelt, Md., May 1971.

Table 1. Apollo 15 sequence of major events

Event	Ground elapsed time, h:min:s	Greenwich Mean Time, h:min:s	Event	Ground elapsed time, h:min:s	Greenwich Mean Time, h:min:s
Launch	00:00:00	Jul 26/13:34:01	End EVA 1	126:14:00	Jul 31/19:48:01
TLI ignition	02:49:48	Jul 26/16:23:49	Bistatic radar begin (Rev 28)	131:42:37	Aug 01/01:16:38
TLI cutoff	02:55:35	Jul 26/16:29:36	Bistatic radar end	132:54:40	Aug 01/02:28:41
First midcourse (TLI + 9 h)	Deleted		Begin EVA 2	142:14:17	Aug 01/11:48:18
Second midcourse (TLI + 27 h)	28:40:00	Jul 27/18:14:01	End EVA 2	149:27:09	Aug 01/19:01:10
Third midcourse (LOI - 22 h)	Deleted		Begin EVA 3	163:18:00	Aug 02/08:52:01
Begin bistatic frequency measurement	60:36:00	Jul 29/02:10:01	CSM plane change	165:12:50	Aug 02/10:46:51
End bistatic frequency measurement	60:43:00	Jul 29/02:17:01	End EVA 3	168:08:00	Aug 02/13:42:01
Fourth midcourse (LOI - 5 h)	73:31:14	Jul 29/15:05:15	LM ascent	171:37:22	Aug 02/17:11:23
SIM door jettison	74:06:14	Jul 29/15:40:15	CSM/LM docking	173:36:00	Aug 02/19:10:01
LOI	78:31:46	Jul 29/20:05:47	LM jettison	179:30:00	Aug 03/01:04:01
S-IVB impact	79:24:41	Jul 29/20:58:42	LM separation	179:50:00	Aug 03/01:24:01
DOI	82:39:48	Jul 30/00:13:49	LM deorbit burn	181:04:19	Aug 03/02:38:20
DOI trim	95:56:43	Jul 30/13:30:44	LM crash	181:29:35	Aug 03/03:03:36
Undock	100:13:30	Jul 30/17:47:31	CSM shaping burn	221:20:47	Aug 04/18:54:48
CSM circularization	101:38:50	Jul 30/19:12:51	P&FS deploy	222:39:36	Aug 04/20:13:37
Powered descent initiation	104:30:09	Jul 30/22:04:10	P&FS signal received	222:55:00	Aug 04/20:29:01
Touchdown	104:42:29	Jul 30/22:16:30	TEI	223:48:45	Aug 04/21:22:46
Begin SEVA	106:42:00	Jul 31/00:16:01	Fifth midcourse (TEI + 15 h)	Deleted	
End SEVA	107:16:00	Jul 31/00:50:01	Begin CSM EVA	241:56:58	Aug 05/15:30:59
Bistatic radar begin (Rev 17)	110:02:45	Jul 31/03:36:46	End CSM EVA	242:36:15	Aug 05/16:10:16
Bistatic radar end	111:15:21	Jul 31/04:49:22	Sixth midcourse (Entry - 22 h)	Deleted	
Begin EVA 1	119:39:40	Jul 31/13:13:41	Seventh midcourse (Entry - 3 h)	291:58:00	Aug 07/17:32:01
ALSEP transmitter activated	125:03:00	Jul 31/18:37:01	Splashdown	295:11:53	Aug 07/20:45:54

Table 2. Apollo 15 television

GMT, h:min	GET, h:min	Duration, h:min	Subject	Vehicle	Station
Jul 26/17:01	03:27	00:08	Transposition and docking	CSM	GDS
Jul 28/00:29	34:55	00:51	Interior and transfer to LM	CSM	GDS
Jul 30/12:28	94:54	00:15	Landing site	CSM	MAD
Jul 31/13:34 ^a	120:00 ^a	06:00 ^b	EVA-1	LM/LCRU	HSK/MAD
Aug 01/11:54 ^a	142:20 ^a	06:30 ^b	EVA-2	LCRU	PKS/HSK/MAD
Aug 02/09:04 ^a	163:30 ^a	04:30 ^b	EVA-3	LCRU	PKS/HSK/MAD
Aug 02/17:04	171:30	00:15	LM liftoff	LCRU	PKS/HSK/MAD
Aug 02/19:00	173:26	00:13	Rendezvous and docking	CSM	MAD
Aug 04/08:57	211:23	00:07	Surface TV	LCRU	MARS
Aug 05/15:24	241:50	01:00	Transearth EVA	CSM	HSK
Aug 06/19:56	270:22	00:52	Press conference and eclipse	CSM	MAD

^aApproximate times.

^bIntermittent coverage.

Table 3. DSS 14 tests

Date, 1971	GMT, h:min	Test
Jul 07	14:00-22:00	Bistatic cable installation
Jul 14		Configuration verification test
Jul 18	01:00-01:00	DSS 14/GDS prime data flow test
Jul 22	09:00-13:00	Bistatic countdown
Jul 22	13:00-20:00	Bistatic test

Table 4. Apollo 15 tracking

DSS	GMT, h:min	Problems
11	Jul 26/16:35-05:38	None.
	Jul 27/19:55-02:50	PA 3 fault at 23:21. One way for 48 s due to erroneous instructions from Prime. Released from track early for troubleshooting.
	Jul 28/20:17-05:50	PA 3 fault at 03:26. Uplink lost for 14 s. High-voltage power supply from DSS 14 installed after pass.
	Jul 29/20:22-05:39	PA 3 fault at 03:21. Uplink lost for 20 s.
	Jul 30/21:39-06:45	PA 3 fault at 02:42 (was in standby).
	Jul 31/22:22-06:19	None.
	Aug 01/23:31-07:55	None.
	Aug 03/00:30-08:44	PA 3 fault at 12:30 on Aug 2 (station inactive).
	Aug 04/02:06-09:10	PA 3 fault at 03:30 (was in standby).
	Aug 05/02:02-10:17	Glitches on HA error voltages. No impact because station autotracking. Problem not repeatable.
	Aug 06/02:21-09:59	None.
	Aug 07/03:04-09:59	PA 3 fault at 04:36. Wrong TLM bandwidth while tracking subsatellite.
14	Jul 27/02:17-05:14	None.
	Jul 28/01:24-05:35	None.
	Jul 28/23:02-05:40	None.
	Jul 29/20:29-05:39	None.
	Jul 30/21:39-06:19	None.

Table 4 (contd)

DSS	GMT, h:min	Problems
14 (contd)	Jul 31/22:29-06:19	Antenna pointing 0.2 deg off boresight for first 10 min of lunar revolution 28.
	Aug 03/00:30-03:35	Failed to switch to high doppler sample rate until 16 min after LM jettison.
	Aug 04/08:51-09:40	None (LCRU track).
	Aug 05/04:00-06:30	None (LCRU search).
42	Jul 27/01:00-13:00	None.
	Jul 28/01:08-13:31	None.
	Jul 29/01:22-13:41	None.
	Jul 30/01:18-14:23	None.
	Jul 31/01:54-14:41	None.
	Aug 01/03:14-16:16	None.
	Aug 02/03:18-17:14	None.
	Aug 03/04:26-17:28	None.
	Aug 04/06:02-19:06	None.
	Aug 05/05:29-19:14	Heat exchanger problem on standby PA.
	Aug 06/05:50-19:25	None.
	Aug 07/06:11-20:26	None.
51	Jul 30/10:17-22:18	Failed to take required doppler data for four of six lunar orbits.
	Jul 31/11:30-22:34	None.
	Aug 03/13:20-01:16	None.
	Aug 04/14:18-21:04	None.
61	Jul 26/09:32-21:19	Bad ranging readouts on System 3; replaced faulty cord.
	Jul 27/12:21-21:56	None.
	Jul 28/12:51-22:06	None.
	Jul 29/13:01-21:55	None.
	Jul 30/14:04-22:38	None.
	Jul 31/15:26-22:33	Pretrack ranging problem; repaired before track.
	Aug 01/15:53-23:43	None.
	Aug 02/16:53-23:45	Wrong character in Tracking Data Processor header.
	Aug 03/18:16-01:21	None.
	Aug 04/18:34-02:22	None.
	Aug 05/18:58-02:23	None.
	Aug 06/19:28-02:30	None.

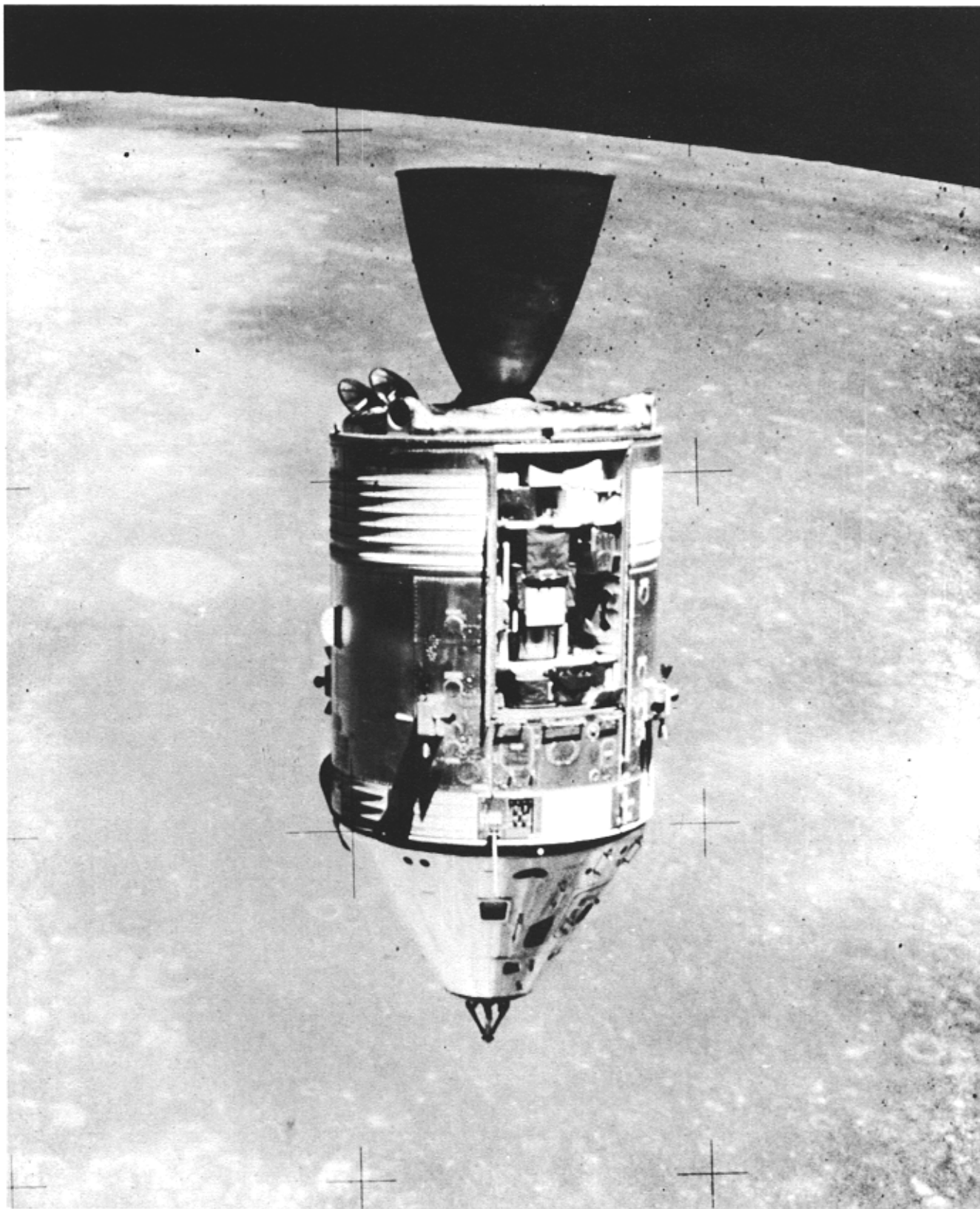


Fig. 1. Scientific Instrument Module Bay of Service Module

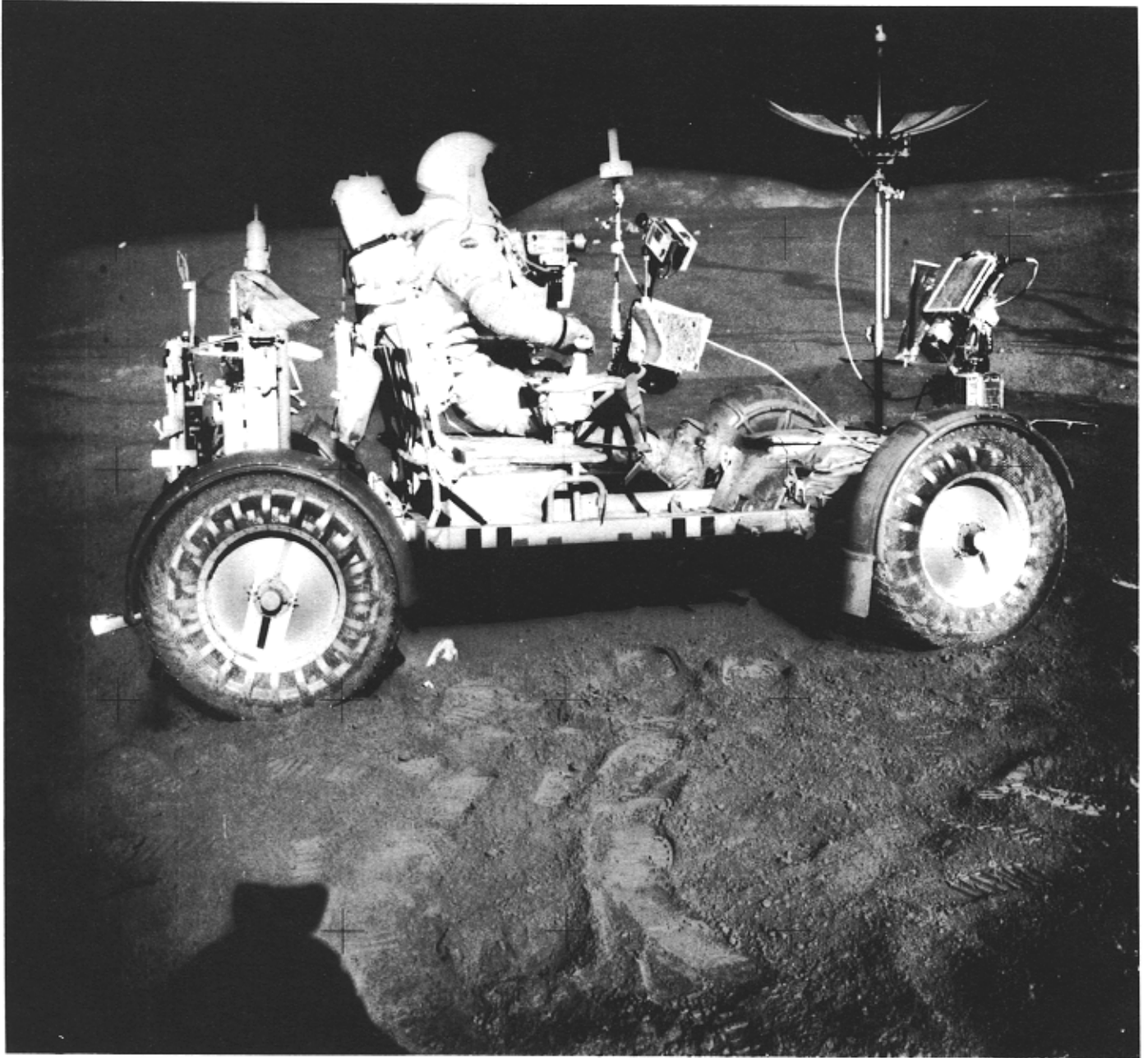


Fig. 2. Apollo 15 Lunar Rover



Fig. 3. View of rover showing ground commanded television camera, lunar communications relay unit, and high- and low-gain antennas

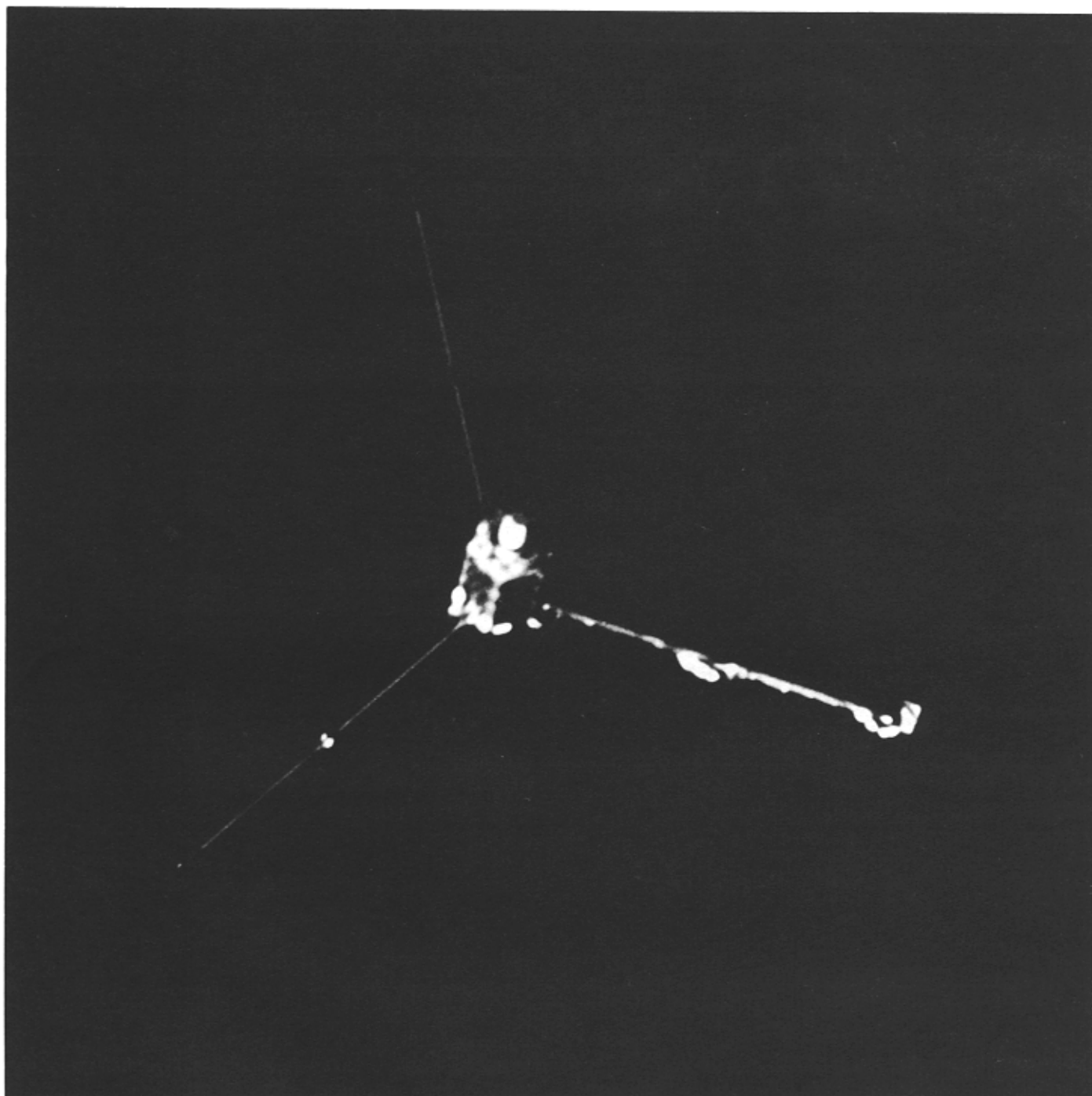


Fig. 4. Particle and fields subsatellite upon release from *Apollo 15* Command and Service Modules